THE RELATIONSHIP OF EDUCATION TO ECONOMIC GROWTH: A CROSS-COUNTRY ANALYSIS

Javad M. Sadeghi

Working Paper 9617

Please address correspondence to: Dr. Javad Sadeghi, College of Agriculture, Isfahan College of Technology, Isfahan 84156, Islamic Republic of Iran. Fax: +(983 1) 891 2528/3112

THE RELATIONSHIP OF EDUCATION TO ECONOMIC GROWTH: A CROSS-COUNTRY ANALYSIS*

J. M. Sadeghi[1]

---

* An earlier draft of this paper was presented at the ERF workshop on " Labor Markets and Human Resource Development" held in Cairo, Egypt on 30 June - 2 July, 1995.

[1] Associate Professor of Agricultural Economics, Isfahan University of Technology, Isfahan, 84156, Iran. The author wishes to thank Professors Aysit Tansel, Ragui Assaad, Ibrahim soliman, Ismail Sirageldin, Massoud Karshenas, and Sulayman Al-qudsi for their helpful comments on the earlier draft of this paper. The author also thanks Ali M. Sadeghi for his help in the computer work of this paper.

Abstract

Simple and piecewise linear regression methods were used on cross-country as well as pooled-cross-country data to estimate the relationship of enrollment ratios to per capita GNP growth. Dummy intercept shifters were used for countries of the OPEC (Organization of Petroleum Exporting Countries) and East Asian Countries (EAC). Dummy variables were also used for the threshold values of the enrollment ratios and for the periods in the pooled regressions. Results showed that: (1) The positive relationship of secondary enrollment ratios to per capita GNP growth were stronger and their estimated regressions better fitted than those of primary ones. (2) The intercept of the estimated regressions - throughout the analysis - shifted downward once the OPEC dummy variable was introduced into the model and shifted upward when the EAC dummy was included. (3) The effect of the enrollment ratios up to the threshold values was much more powerful on economic growth than was that beyond the threshold values. (4) Pooled estimated enrollment/ economic growth regressions showed some negative structural change in the periods 1980 and 1992 as compared to the reference period 1950.

ملخص

تم تطبيق أساليب انحدار خطية بسيطة ومجزأة على بيانات مقارنة عبر الأقطار و بيانات مقارنة مجمعة عبر الأقطار، وذلك لتقييم علاقة معدلات الالتحاق بالمدارس بنمو نصيب الفرد من الناتج القومي الاجمالي. وقد تم استخدام متغيرات تعارض وهمية في حالة دول منظمة الأقطار المصدرة للنفط (الاوبك) ودول شرق آسيا. كما تم استخدام متغيرات تعارض القيم الحدية لمعدلات الالتحاق وللفترات المضمنة في الانحدارات المجمعة. وتبين النتائج أن: (١) معدلات العلاقة الايجابية للالتحاق بالتعليم الثانوي بالنسبة لنمو نصيب الفرد من الناتج القومي الاجمالي كانت أقوى بالاضافة إلى أن الانحدارات المقدرة كانت أكثر ملائمة من تلك المعدلات والانحدارات في التعليم الابتدائي. (٢) تعارض الانحدارات المقدرة في التحليل بأكمله يتجه إلى أسفل عند اضافة متغير الاوبك الوهمي للنموذج ، في حين يتجه إلى أعلى عند اضافة المتغير الوهمي لدول شرق آسيا للنموذج. (٣) أثر معدلات الالتحاق على النمو الاقتصادي كان أقوى قبل الوصول إلى القيم الحدية منه بعد تخطي هذه القيم. (٤) تشير الانحدارات المجمعة المقدرة للالتحاق/ النمو الاقتصادي المتراجع إلى بعض التغيرات الهيكلية السلبية في الفترات بين ١٩٨٠ و١٩٩٢ بالمقارنة بفترة ١٩٥٠ المرجعية.

INTRODUCTION

Education is an important dimension of human capital. As such, the relationship of education to economic growth deserves close examination. Despite assertions made by economists that the expansion of education is an effective long-run strategy for economic growth (Schultz, 1961, 1981; Todaro, 1989, p. 345; Tilak, 1989, pp 10-23), this strategy has been overlooked in some developing countries (Reimers and Tiburico, 1993)[2]. Hence, studies of this kind seem to be pursued.

Several studies have been conducted on the relationship of education to economic growth. In most of these studies, the relationship has been found to be positive. A summary of these studies, as well as those on the relationship of education to poverty and income distribution, is presented in Tilak (1989, pp. 10-63). The methodologies utilized to examine the relationship of education to economic growth are summarized by Tilak (1989, pp. 10-23) and include the historical narrative approach, correlation analysis, regression analysis, production functions, simultaneous equations, and rate of return. Although the results of these empirical studies generally show a positive relationship between education and economic growth, there are differences in terms of the magnitude of the relationship as well as the way of explaining the effects. In addition, these studies differ in terms of the country or the geographical area covered, the type of data and the length of time considered, and the types of the models and the variables used for their analyses.

Studies by Aukrust (1959); Denison (1962); Jorgenson (1984) focused on a single country while others such as Krueger (1968) and Kothari (1970) used cross-country data for their analyses. Tilak (1986) classified 75 countries into four categories in order to specify their differences with respect to the education/economic growth relationship. Different variables and variable specifications have been used in comparable studies as well. Most of these studies have used per capita income growth as the dependent variable and several different kinds of explanatory variables, including literacy level (Hicks, 1980) and enrollment ratios (Marris, 1982; Lau *et al.*, 1991; Glaeser 1993; and Cohen and Hammour, 1994). Lau *et al.* (1991) regressed a cross-country aggregate production function. Among other regressions, Lau, *et al.* regressed the aggregate real output on quantitative variables of capital, land, labor, and level of schoolings and the dummy variables for different geographical areas. Cohen and Hammour (1994) using Solow (1956) production function model studied the cross-country relationship among different macro variables. For example, they regressed per capita income on physical capital, human capital, population growth, and initial income level. Glaeser (1993) in his cross-country analysis divided education's effect on economic growth into three parts: (1) an effect of change in the returns to schooling over time; (2) an indirect effect due to schooling's positive effect on schooling growth; and (3) a direct effect due to education's raising income growth even holding education growth constant. Glaeser (1993) used variables of per capita GDP and secondary school enrollment ratio in his regression analysis. He avoided to include other explanatory variables in order to keep the model simple.

---

[2] Education is here referred to in its broad sense without differentiating between general education and vocational training. For the difference see, for example, Singer (1976 pp. 399-400).

The general objective of the present study is to shed more light upon the education/economic growth relationship. Specifically, this study focuses on the following four objectives:

1) The first objective is to explore the relationship of school enrollment ratio to economic growth across various countries[3];

2) The second objective was to determine whether the relationship of enrollment ratios to economic growth differs at a statistically significant level for the Organization of Petroleum Exporting Countries (OPEC) and/or for the East Asian Countries (EAC) from that of other countries under investigation due to economic structural differences. OPEC was categorized because it has relied mainly on a single exporting commodity--oil--for its foreign exchange supply. EAC was categorized because it has experienced a high and sustained level of economic growth over the last 25 years (World Bank, 1993);

3) The third objective is to see whether there has been any structural change over time - leading to a shift in the intercept of the estimated enrollment/economic growth regressions; and

4) The fourth objective is to investigate whether the slope of the regression line between enrollment ratio and economic growth remains constant regardless of the level of enrollment ratio.

METHODS AND DATA

A linear regression model was used on cross-country data--for the seven periods of 1950, 1955, 1960, 1965, 1970, 1980, and 1992--to estimate the relationship of enrollment ratio to economic growth[4]. Dummy variables were included in the model to estimate the possible shifts in the intercept of the regressions for the two categories of countries: OPEC and EAC. For the analyses in the third and fourth objectives, cross-country data for the seven periods were pooled. For the third objective, by inserting a dummy variable for each period the shift in the intercept of the underling regressions were tested. The dummy for the year 1950 was omitted in order to consider 1950 as the reference period. For the fourth objective a piecewise linear regression model (Gujarati, 1988 pp 454-456) was used to estimate the possible threshold for the level of enrollment ratios affecting economic growth. This step was included to find out whether the slope of the regression lines changes at threshold values.

Growth of per capita GNP in constant terms was taken as the dependent variable throughout the study[5]. The quantitative explanatory variable was school enrollment ratios[6], used as the proxy for level of education. The qualitative variables in the different regressions included nine dummies:

---

[3] This is not something new to explore; however, it was included as a part of the analysis in order to make the use of covariance framework possible for the second, third, and fourth objectives.

[4] In this paper, the results of the estimated regressions that used economic growth rather than the quantity of output as the dependent variable are presented. The reason is that autocorrelation were observed--on the basis of their estimated Durbin-Watson statistics--in almost all of the estimated regressions in which the quantity of output was used as the dependent variable. Nonetheless, the quantity of output has been used for this kind of analysis though in somewhat different models (Lau, *et al.*, 1991; Cohen and Hammour, 1994; and Glaeser, 1994).

[5] Equations with logarithmic values of the dependent variable were not run due to the existence of negative sign for some of the per capita GNP growth.

[6] The enrollment ratio of secondary schooling for female, male, and total populations were presented in the models and in the results. For primary schooling only total population was presented, however. The reasons were that the results that used primary enrollment of female and male were not highly significant or it was deemed necessary to make the paper short.

two for OPEC and EAC, six for the different periods, and one for the threshold values in the piecewise regressions. Other variables such as literacy level, initial income, and investment were inserted into the regressions whenever it was appropriate. However, the full estimated results of these other variables are not presented in the paper because the results did not show a high level of significance or it was thought necessary to keep the paper short.

The linear regression equation used to estimate the relationship of enrollment ratio to economic growth and the effects of OPEC and EAC dummies - first and second objectives - was as follows:

$$Q_i = \alpha + \beta_1 E_i + \beta_2 D_{2i} + \beta_3 D_{3i} + u_i \qquad (1)$$

where:

Q_i = per capita GNP growth in constant terms between 1980 to1993 and measured in U.S Dollars for country i.

E_i = school enrollment ratio (gross) for country i, measure as the percentage of school age population actually enrolled. The enrollment ratio, E_i, was applied in separate regressions to the total population in the primary school and to the female, male, and total populations in the secondary school enrollment ratios for the years 1950, 1955, 1960, 1965, 1970, 1980, and 1992.

D_{2i} = Dummy variable, with a value of one for the OPEC countries included in this study (Algeria, Gabon, Nigeria, Ecuador, Venezuela, Indonesia, Kuwait, Saudi Arabia, and The United Arab Emirates) and of zero for the other countries.

D_{3i} = Dummy variable, with a value of one for the EAC countries included in this study (Hong Kong, Japan, Malaysia, Singapore, Indonesia, Republic of Korea, The Philippines, and Thailand) and of zero for the other countries.

i = Countries of 1, 2, ..., 98[7].

α = intercept for equation (1).

$\beta 1..\beta_3$ = regression coefficients for equation (1).

u_i = regression residual for country i in equation (1).

The linear regression equation using pooled data to estimate the structural change in the enrollment/economic growth relationship - the third objective - was as follows:

$$Q_{it} = \alpha + \beta_1 E_{it} + \beta_2 D_{2it} + \beta_3 D_{3it} + \beta_4 D_{4it} + \beta_5 D_{5it} + \beta_6 D_{6it} + \beta_7 D_{7it} + \beta_8 D_{8it} + \beta_9 D_{9it} + u_{it} \qquad (2)$$

where:

Q_{it} and E_{it} = defined as Q_i and E_i in equation (1) with their values in the periods t. The enrollment ratio, E_{it}, was applied in separate regressions to the total population In the first and to the female, male, and total populations of the second level of enrollment ratios.

D_{2it}, and D_{3it} = the same as D_{2i} and D_{3i} in equation (1) repeated in the periods t.

$D_{4it}..D_{9it}$ = dummy variables with the value of one for either of the periods: 1955, 1960,

[7] See footnote 8.

1965, 1970, 1980, and 1992, respectively and zero otherwise.

i = the same as in equation (1).

t = periods of 1950, 1955, 1960, 1965, 1970, 1980, and 1992.

α = intercept for equation (2).

$\beta_1..\beta_9$ = regression coefficients for equation (2).

u_{it} = regression residual for country i in period t in equation (2).

The piecewise linear regression equation using pooled data to estimate the threshold value of the enrollment ratio in the enrollment/economic growth relationship - the fourth objective - was as follows:

$$Q_{it} = \alpha + \beta_1 E_{it} + \beta_2 D_{2it} + \beta_3 D_{3it} + \beta_4 (E_{it} - E^*) D_{10it} + u_{it} \quad (3)$$

where:

Q_{it}, E_{it}, D_{2it}, D_{3it}, i, and t = the same as in equation (2).

E^* = threshold value of enrollment ratio, E.

D_{10it} = dummy variable, with a value of one if E_{it} was larger than E^* and of zero if E_{it} was equal to or smaller than E^*.

α = intercept for equation (2).

$\beta_1..\beta_4$ = regression coefficients for equation (2).

u_{it} = regression residual for country i in period t in equation (2).

Regression results were compared according to their F ratios, R^2's, and Durbin-Watson statistics for the whole regressions, as well as to the sign and values of the t statistics of the estimated partial regression coefficients.

The data used in this study for per capita GNP, per capita GNP growth, enrollment ratios, 1990 literacy level, population, population growth, and 1970 and 1992 enrollment ratios were taken or derived from The World Bank (1995); 1970 literacy level, and the 1950, 1955, 1960, 1965, and 1980 enrollment ratios were taken mainly from published figures in different years of the *UNESCO, Statistical Yearbook*; and for investment from Summers and Heston (1991). OPEC and EAC were listed from the PC Globe 5.0 Package. For each regression, only the countries that had data for that regression were included[8]. Consequently, the number of observations of the estimated regressions varied accordingly. The results of including every one of these variables in

[8] These countries included: *Africa*: Algeria, Benin, Bostwana, Burkina Faso, Burundi, Cameroon, Central African Republic, Chad, Congo, Côte d'Ivoire, Egypt Arab Republic, Gabon, Gambia, Ghana, Guinea-bissau, Kenya, Lesotho, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, South Africa, Togo, Tunisia, Zambia, Zimbabwe; *Europe*: Austria, Belgium, Bulgaria, Denmark, Finland, France, Hungary, Greece, Irland, Italy, The Netherlands, Norwey, Poland, Portugal, Romania, Spain, Sweden, United Kingdom, Switzerland; *North America*: Canada, Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Jamaica, Mexico, Nicaragua, Panama, Puerto Rico, Trinada and Tobago, The United States; *Oceania*: Australia, New Zealand, Papua New Guinea, *South America*: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, Venezuela; *Asia*: Bangladesh, Hong Kong, India, Indonesia, Israel, Japan, Kuwait, Malaysia, Nepal, Pakistan, Philippines, Republic of Korea, Saudi Arabia, Singapore, Sri Lanka, Thailand, Turkey, and United Arab Emirates.

the regressions are not shown due to either low significancy of the estimated coefficients or to keep the paper short.

RESULTS AND DISCUSSION

A. The Relationship of Enrollment Ratios to Economic Growth

In Tables 1 and 2, the results of the estimated regressions using equation (1) are presented. Table 1 is for the primary and Table 2 is for the secondary schooling. Table 1 contains seven regressions that correspond to the enrollment ratio data of 1950, 1955, 1960, 1965, 1970, 1980, and 1992. In addition to the enrollment ratios, the dummy variables for OPEC and EAC were also included in all the regressions.

In Table 1, the F ratios and the Durbin-Watson statistics of all the estimated regressions were statistically significant at 1 % level. The estimated coefficients for enrollment ratios were statistically significant only for 1950, 1955, 1960, and 1992. The estimated coefficient of 1992 enrollment ratio was the largest in value--that is, 0.0291--and with the highest statistical significance among the seven periods under consideration. These results may support the assumption that education is not only the seed but also the fruit of economic growth.

The intercept of the estimated regression lines between primary enrollment ratio and economic growth shifted downward once the OPEC dummy variable was introduced into the model and shifted upward when the EAC dummy was included. The negative relationship of OPEC and positive relationship of EAC to economic growth, with the exception of 1950, were all statistically significant.

Table 2 shows the relationship of secondary enrollment ratios to per capita GNP growth of female, male, and total populations. It contains 21 regressions that are divided into seven sets of three regressions. Each set in turn corresponds to the enrollment ratio data of 1950, 1955, 1960, 1965, 1970, 1980, and 1992, and each regression in the set corresponds to the female, male, and total populations. Here again, in addition to the enrollment ratios, the dummy variables for OPEC and EAC were also included in all the regressions.

In Table 2, the F ratio and Durbin-Watson statistics of all regressions as well as t statistics for all of the estimated partial coefficients, with two exceptions in 1955, were statistically significant. Comparing regressions of Table 1--primary schooling--to corresponding regressions of Table 2--secondary schooling--it is observed that the regressions of secondary schooling are generally better fitted than those of primary schooling. That is, regressions of secondary enrollment ratios have generally larger R^2's, F ratios, and t statistics than those of primary level. The values of the estimated partial coefficient of the secondary enrollment ratios, with the exception of 1992, are larger than those of the corresponding coefficients of primary enrollments. This finding is not consistent with the results of Psacharopoulos (1973, p. 119) that the contribution of primary education is much higher than those of higher education and of secondary education[9]. The

[9] The regressions 18 and 21 in Table 2 were reestimated substituting tertiary enrollment ratios of 1980 and 1992 for which data were available, respectively. The results showed statistically significant values of 0.0386 and 0.0300 for

estimated coefficients for the secondary enrollment ratio shown in Table 2, ranged from 0.0166 to 0.0293, 0.0180 to 0.0359, and 0.0176 to 0.0346 for the female, male, and total populations, respectively. The largest value for the estimated coefficient of enrollment ratios was found in the female, male, and total populations of 1955.

Similar to the results of primary schooling in Table 1, the intercept of the estimated regression lines of the secondary schooling in Table 2 shifted downward once the OPEC dummy variable was introduced into the model and shifted upward once the EAC dummy was included. The negative relationship of OPEC and positive relationship of EAC to economic growth, with the exception of 1950 and 1955 of OPEC, were all statistically significant.

B. Enrollment / Economic Growth Relationship and the Structural Change - Using Pooled Data

The third objective was to see whether there has been any structural change in the enrollment/economic growth relationship. Table 3 shows the six estimated regressions using equation (2) and the pooled cross-section data of 1950, 1955, 1960, 1965, 1970, 1980, and 1992. In Table 3, regressions 1 and 2 belong to primary enrollments of total population and regressions 3 and 4 for secondary female and male, respectively; and regressions 5 and 6 for secondary total populations. Regressions 2 and 6 contained dummy variables for the different periods. However, the other four regressions lacked these dummies.

Estimated regressions of Table 3 had larger f ratios and t statistics for the partial coefficients of enrollment ratios and OPEC and EAC dummy variables than the corresponding regressions in Tables 1 and 2. This shows that the regressions with pooled data explain the enrollment/economic growth relationship better than those with separate cross-section data. The value of the estimated partial coefficient for secondary enrollment of total population is 0.0195--regression 5 in Table 3. This is larger than 0.0122 which is the corresponding figure for the primary level--regression 1 in Table 3.

The estimated partial coefficient of dummy variables of the six period, D_{4it} to D_{9it} of regression 2 in Table 3, were not statistically significant. That is, there is no significant structural change--shift in the intercept-in the regressions of primary enrollment/economic growth relationship. In regression 6 of Table 3 for secondary enrollments, however, the estimated partial coefficients for the dummy variables of 1980 and 1992, D_{8it} and D_{9it}, were with negative sign and significant at 10% level. This implies some negative structural change in the periods 1980 and 1992 as compared to the reference period 1950[10] in the secondary enrollment/economic growth relationship. As compared to 1950, this might imply that in 1980 and 1992 less favourable conditions were available to take advantage of education for economic growth.

---

the estimated partial coefficients of the tertiary enrollments of 1980 and 1992. These were larger than the corresponding figures for the secondary enrollments that were 0.0176 and 0.0241 (regressions 18 and 21 in Table 2) and the primary enrollments that were 0.0118 and 0.0291 (regressions 6 and 7 in Table 1).

[10] The periods 1980 and 1992 were compared to the other periods such 1970, by omitting the dummies of the other periods from the regression. The results did not show any statistically significant changes in the intercept. Therefore, the structural change in 1980 and 1992 is valid when these periods are compared to 1950 and not to the earlier periods.

Similar to cross-section regressions, presented in Tables 2 and 3, statistically significant negative effect of OPEC and positive effect of EAC are evident from the estimated coefficients of their dummy variables, D_{3it} and D_{4it}, in the pooled regressions in Table 3.

C. Enrollment / Economic Growth Relationship and the Threshold Value for Enrollment Ratios - Using Pooled Data

Piecewise linear regression, equation (2), and pooled data were employed to estimate the threshold value of the enrollment ratio in the enrollment/economic growth relationship. The estimated results are shown in Table 4. In this Table, regression 1 belongs to primary enrollment of total population and can be compared with regression 1 of Table 3; Regressions 2, 3, and 4 belong to secondary enrollments of female, male, and total populations and can be compared with regressions 3, 4, and 5 of Table 3, respectively. The four regressions in Table 4 are statistically significant in terms of their F ratio, and Durbin-Watson statistics and t values of the estimated partial coefficients. Different threshold values were tried for the enrollment ratios but only the most statistically significant ones are presented in Table 4. The threshold value for primary enrollment of total population E^* was 42% (regression 1 in Table 4). Similarly the threshold values E^*s for secondary enrollment of female, male, and total populations were 23, 53 and 36%, respectively (regressions 2, 3, and 4 in Table 4).

The estimated two-segment piecewise lines of the regressions in Table 4 are shown in Figures 1 to 4. Their corresponding regressions in Table 3 that lack threshold value are also shown in the Figures for comparison. In this analysis, given that the sign for each estimated coefficient ($ß_{10it}$) of the threshold dummy (D_{10it}) in Table 4 and Figure 1 to 4 were negative, the second segments of the regression lines were less steep[11]. In contrast, the slope of the first segment of the piecewise regressions became much steeper than that of the corresponding regressions in Table 3 when the dummy variable for the threshold value was included (Compare, for example, $ß_{1it}$ of regression 4 in Tables 4 to that of regression 5 in Table 3--that is, 0.0465 and 0.0195). The slope of the first segment of the regression line ($ß_{1it}$) of the estimated regression 4 of Table 4 was 0.0465, and the slope of the second segment was 0.0218--i.e, 0.0465 - 0.0247. It is interesting to note from Table 3 that the slope of the regression line in regression 5 was 0.0195. This value lies somewhere between the slopes of the two segments of the regression line in regression 4 of Table 4--see Figure 4 as well. This phenomenon may not always hold, however, since the slopes of two segments of a piecewise regression line depend partly on the value of the threshold and the fit of the regression.

Accordingly it can be concluded from regressions in Table 4 that, up to the statistically significant threshold value of 42 percent the primary enrollment ratio of total population was much more effective on economic growth than those beyond the threshold values (given that the $ß_{10it}$'s were negative). The same conclusion can made for secondary education of female, male, and total populations at 23, 53, and 36 percent enrollment ratios, respectively.

[11] The slope of the second segment of each of the regression lines is calculated as $ß_{1it}$ plus $ß_{10it}$ -- that is, the coefficient of E_{ti} and D_{10it} respectively (Gujarati, P. 455).

The average of the slopes of the two segments of the regression line for the estimated regressions in Table 4 was larger than that of the corresponding regression line in Table 3. In fact, even the second segment of regressions in Table 4 had a larger estimated coefficient than did the corresponding regressions in Table 3, as can be seen when $ß_{1it} + ß_{10it}$ of each of the regressions in Table 4 is compared with $ß_{1it}$ of the corresponding regressions in Table 3. It is, therefore, important to mention that introducing the threshold dummy variable increased the effect of the enrollment ratio in the first as well as the second segments of all pooled regressions; and (2) not including the threshold dummy variable in the regressions would have underestimated the effects of the enrollment ratios in this analysis.

In the estimated regressions in Table 4, the negative effects of OPEC and the positive effects of EAC on economic growth were again observed. The question of what caused the negative effect by OPEC and the positive effect by EAC is indeed interesting to explore but is beyond the scope of this study.

SUMMARY AND CONCLUSIONS

The four objectives of this study were as follows: (1) to explore the relationship of school enrollment ratio to economic growth across various countries; (2) to determine whether the relationship of enrollment ratios to economic growth differs for OPEC and/or for EAC from that of other countries under investigation due to economic structural differences; (3) to see whether there has been any structural change over time - leading to a shift in the intercept of the estimated enrollment/economic growth regressions; and (4) to investigate whether the slope of the regression line between enrollment ratio and economic growth remains constant regardless of the level of enrollment ratio. Linear and piecewise regression methods, cross-country data of different periods, and pooled-cross-country data were employed in the analyses.

In the cross-country and-pooled cross-country analysis, the relationship of primary enrollment ratios, and secondary enrollment ratios to per capita GNP growth were positive and statistically significant. The cross-section estimated results showed that the regressions of secondary enrollment/economic growth relationships were generally better fitted than those of primary regressions. And the relationships--i.e., the value of the estimated coefficients--for secondary enrollments ratios were generally stronger than those of primary ones.

Regressions with pooled data in Table 3 explained the enrollment/economic growth relationship better than those with separate cross-section data. The estimated regressions using pooled data showed stronger enrollment/economic growth relationship for secondary education than primary education as well. This finding is not consistent with the results of Psacharopoulos (1973, p. 119) that the contribution of primary education is much higher than that of higher education and that of secondary education. The value of the estimated partial coefficient for secondary enrollment of total population was 0.0195. This was larger than 0.0122 that was the corresponding figure for the primary enrollment.

Pooled estimated regressions showed some negative structural change in the periods 1980 and 1992 as compared to reference period 1950. This might imply that, as compared to 1950, in 1980

and 1992 less favourable conditions prevailed to take advantage of education for economic growth.

The estimated results of piecewise regressions in the enrollment/economic growth relationship showed the threshold value (E^*) as follows: forty two percent for primary enrollment of total population; and 23, 53, and 36 percent for secondary enrollment of female, male, and total populations, respectively. From the explanations given in section C of the results section, two points with regard to threshold values can be concluded. First, the effects of the primary and secondary enrollment ratios of up to the threshold values were much more powerful on economic growth than were those beyond the threshold values. Second, not including the threshold dummy variable in the regressions would have resulted in underestimating the effects of the enrollment ratios in this analysis.

The intercept of the estimated regression lines between primary as well as secondary enrollment ratios and economic growth shifted downward once the OPEC dummy variable was introduced into the model and shifted upward when the EAC dummy was included. These shifts were observed in all estimated regressions using either cross-section or pooled data and whether or not the threshold dummy variable was included in the regressions. This finding may indicate that in spite of the positive effects of primary and secondary enrollment ratios on per capita GNP growth, some factor or factors inhibited economic growth in OPEC during 1980-1993; likewise, some factor or factors stimulated growth in EAC. The question of what caused the negative effect by OPEC and the positive effect by EAC is indeed interesting to explore but is beyond the scope of this study.

BIBLIOGRAPHY

Aukrust, O. (1959) "Investment and Economic Growth," reprinted in *Readings in the Economics of Education*, edited by M. J. Bowman, M, Debeauvais, V. Komarove, and J. Vaizey, Paris: UNESCO, 1968, pp. 190-204.

Cohen, D. and M. L. Hammour (1994) "Economic Growth in the Middle East and North Africa: An International perspective", Working Paper 9403, Cairo: Economic Research Forum for the Arab Countries, Iran and Turkey.

Denison, E.F. (1962) "Sources of Economic Growth in the United States and the Alternatives Before us", Supplementary Paper No. 13. New York: Committee for Economic Development.

Glaeser, E. L. (1994) "Why Does Schooling Generates Economic Growth?" *Economics Letters*, 44 pp. 333-337.

Gujarati, D. N.(1988) *Basic Econometrics*, New York: McGraw-hill Book Company.

Hicks, Norman (1980) "Economic Growth and Human Resources", Staff Working Paper No. 408, Washington D.C.: Word Bank.

Jorgenson, Dale W. (1984) "The Contribution of Education to US Economic Growth: 1948-73," *in Education and Economic Productivity*, edited by Edwin Dean, Cambridge: Ballinger, 1984, pp. 95-162.

Kothari, V. N. (1970) "Disparities in Relative Earnings Among Different Countries," *Economic Journal* 80 (319), September, pp. 605-16.

Krueger. Anne O. (1968) "Factor Endowments and Per Capita Income Differences among Countries," *Economic Journal*, 78 (311), September, pp. 641-59.

Lau, L. J., D. T. Jamison, and F. F. Louat (1991) "Education and Productivity in Developing Countries - An Aggregate Production Function Approach, Working Paper", Washington D. C.: The World Bank.

Marris, Robin (1982) "Economic Growth in Cross Section: Experiments with Real Product Data, Social Indicators, Model Selection Procedures, and Policy Benefit/Cost Analysis", Discussion Paper, London: University of London, Birbeck, Department of Economics.

Psacharopoulos, G. (1973) *Returns to Education: An International Comparison*, Amsterdam: Elsevier.

Reimers, F. and L. Tiburcio, (1993) *Education Adjustment and reconstruction: Options for Change,* A UNESCO Policy Discussion Paper, France: UNESCO Publishing.

Schultz, Theodore W. (1961) "Investment in Human Capital," *American Economic Review* 51 (1) March, pp. 1-17.

Schultz, Theodore W. (1981) "Investing in People", in *Agricultural Development in the Third World*, edited by Carl K. Eicker, and John M. Staatz, Baltimore: the Johns Hopkins University Press, second ed., 1990, pp. 280-89.

Singer, Neil M. (1976) *Public Microeconomics an Introduction to Government Finance*, second ed., Boston: Little, Brown Company, pp. 399-400.

Solow, R. M. (1956) "A Contribution of the Theory of Economic Growth", *Quarterly Journal of Economics*, 70 pp. 65-94.

Summers, R. and A. Heston (1991) "The Penn World table (Mark 5): an Expanded Set of International Comparison, 1950- 1988" *Quarterly Journal of Economics*, 106, May, pp. 327-368.

Tilak, Jandhyala B.G. (1986) "Education in an Unequal World", in *Educational Planning: A Long Term Perspective,* New Delhi: Concept Publishers for National Institute of Educational Planning and Administration, pp. 27-50.

Tilak, Jandhyala B. G. (1989) *Education and Its Relation to Economic Growth, Poverty, and Income Distribution Past Evidence and Further Analysis*, World Bank Discussion Papers, Washington, D. C.: The World Bank.

Todaro, Michael P. (1989) *Economic Development in the Third World*, fourth ed., New York: Longman.

UNESCO (1970, 1986, 1987, and 1994) *Statistical Yearbooks*.

World Bank, *(1993) The East Asian Miracle: Economic Growth and Public Policy*, A World Bank Policy Research Report, Oxford University Press.

_____(1995) *World Development Report 1995--Workers in an Integrating World*, Oxrord: Oxford University Press.

Table 1. Estimated regression coefficients for the cross-country relationship of the primary enrollment ratios of total population 1950, 1955, 1960, 1965, 1970, 1980, and 1992, OPEC, and EAC to per capita GNP growth of 1980-93, using equation (1).

	1950	1955	1960	1965	1970	1980	1992
Regression number	1	2	3	4	5	6	7
Explanatory variables[a]:							
G_{ei}	0.0138**	0.0124*	0.0123*	0.0114	0.0093	0.0118	0.0291***
	(2.02)[b]	(1.76)	(1.67)	(1.48)	(1.20)	(1.19)	(2.72)
D_{2i}	-1.3778	-1.7170*	-1.6057*	-1.8570*	-2.2978***	-1.9885**	-2.6659***
	(-1.54)	(-1.70)	(-1.94)	(-2.26)	(-3.13)	(-2.13)	(-3.25)
D_{3i}	4.3603***	3.4062***	3.4201***	4.3486***	4.9779***	4.2179***	4.7817***
	(4.03)	(3.64)	(3.60)	(4.93)	(5.99)	(5.08)	(4.95)
R^2	0.302	0.255	0.222	0.301	0.361	0.285	0.355
R^2 (adj.)	0.267	0.222	0.190	0.274	0.339	0.259	0.330
F-ratio	8.79***	7.55***	6.86***	11.21***	16.35***	11.02***	14.45***
n_1, n_2	3,60	3,66	3,72	3,78	3,87	3,83	3,79
D-W	2.11***	2.09***	2.13***	1.84***	2.06***	1.88***	2.04***
k,n	3,65	3,70	3,76	3,82	3,91	3,87	3,83
SEE	2.0783	2.1679	2.2129	2.2026	2.0863	2.1994	2.0629
Intercept	-0.5271	-0.3589	-0.5514	-0.4524	-0.2969	-0.6316	-2.0888**
	(-1.08)	(-0.68)	(-0.93)	(-0.68)	(-0.34)	(-0.68)	(-2.09)

* Significant at 10% level.

** Significant at 5% level.

*** Significant at 1% level.

[a] Definition of the variables are given under equations (1).

[b] Figures in parentheses are t values for the estimated coefficients.

Table 2. Estimated regression coefficients for the cross-country relationship of the secondary enrollment ratios of 1950, 1955, 1960, 1965, 1970, 1980, and 1992, OPEC, and EAC to per capita GNP growth of 1980-93, using equation (1).

	1950			1955		
	Female	Male	Total	Female	Male	Total
Regression number	1	2	3	4	5	6
Explanatory variables[a]:						
E_i	0.0268	0.0263*	0.0282	0.0274*	0.0359***	0.0346**
	(1.46)[b]	(1.72)	(1.65)	(1.82)	(2.97)	(2.51)
D_{2i}	-1.3163	-1.2962	-1.2927	-1.2771	-1.1637	-1.1952
	(-1.37)	(-1.36)	(-1.35)	(-1.26)	(-1.19)	(-1.20)
D_{3i}	5.2260***	4.5950***	5.0617***	3.6840***	3.2642***	3.4469***
	(3.90)	(3.66)	(3.75)	(3.91)	(3.53)	(3.70)
R^2	0.290	0.308	0.305	0.282	0.335	0.311
R^2 (adj.)	0.262	0.272	0.269	0.248	0.304	0.280
F-ratio	8.09***	8.47***	8.35***	8.49***	10.92***	9.80***
n_1, n_2	3,57	3,57	3,57	3,65	3,65	3,65
D-W	1.71***	1.66***	1.69***	1.88***	1.84***	1.87***
k,n	3,61	3,61	3,61	3,69	3,69	3,69
SEE	2.2076	2.1922	2.1968	2.1596	2.777	2.1142
Intercept	0.0052	-0.0735	-0.536	-0.0088	-0.3071	-0.1917
	(0.01)	(-0.20)	(-0.15)	(-0.03)	(-0.88)	(-0.55)

Table 2. Continued...

Table 2. Continued . . .

	1960			1965		
	Female	Male	Total	Female	Male	Total
Regression number	1	2	3	4	5	6
Explanatory variables[a]:						
E_i	0.0293*	0.0350**	0.0311**	0.0206**	0.0246**	0.0238**
	(1.81)[b]	(2.62)	(2.25)	(2.01)	(2.50)	(2.32)
D_{2i}	-1.8704*	-1.9020**	-1.8758*	-1.8461**	-1.8583**	-1.8385**
	(-1.92)	(-2.00)	(-1.95)	(-2.08)	(-2.13)	(-2.09)
D_{3i}	3.9482***	3.6772***	3.8171***	4.044***	3.9113***	3.9617***
	(4.30)	(4.07)	(4.18)	(4.23)	(4.13)	(4.17)
R^2	0.314	0.347	0.331	0.299	0.317	0.110
R^2 (adj.)	0.284	0.318	0.301	0.271	0.291	0.283
F-ratio	10.37***	12.03***	11.19***	10.93***	11.93***	11.53***
n_1, n_2	3,68	3,68	3,68	3,77	3,77	3,77
D-W	2.12***	2.13***	2.13***	1.95***	1.97***	1.96***
k,n	3,72	3,72	3,72	3,81	3,81	3,81
SEE	2.2710	2.2160	2.2433	2.2157	2.1858	2.1977
Intercept	0.0296	-0.2587	-0.1227	-0.0339	-0.2482	-0.1690
	(0.08)	(-0.66)	(-0.32)	(-0.91)	(-0.63)	(-0.44)

Table 2. Continued ...

Table 2. Continued ...

	1970			1980		
	Female	Male	Total	Female	Male	Total
Regression number	1	2	3	4	5	6
Explanatory variables[a]:						
E_i	0.0204**	0.0236***	0.0224***	0.0166**	0.180**	0.0176**
	(2.56)[b]	(2.83)	(2.72)	(2.31)	(2.19)	(2.28)
D_{2i}	-2.0306***	-2.0636***	-2.0400***	-1.7280**	-1.7826**	-1.7509**
	(-2.77)	(-2.85)	(-2.80)	(-2.05)	(-2.11)	(-2.07)
D_{3i}	5.0093***	4.9156***	4.9619***	4.0043***	4.0445***	4.0186***
	(6.17)	(6.08)	(6.13)	(5.01)	(5.05)	(5.02)
R^2	0.400	0.408	0.404	0.325	0.320	0.323
R^2 (adj.)	0.377	0.387	0.383	0.299	0.295	0.298
F-ratio	18.59***	19.30***	19.01***	12.82***	12.57***	12.75***
n_1, n_2	3,84	3,84	3,84	3,80	3,80	3,80
D-W	2.01***	2.06***	2.03***	1.93***	1.92***	1.93***
k,n	3,88	3,88	3,88	3,84	3,84	3,84
SEE	2.0549	2.0388	2.0455	2.1271	2.1341	2.1291
Intercept	-0.1290	-0.3392	-0.2419	-0.1654	-0.2996	-0.2455
	(-0.38)	(-0.90)	(-0.67)	(-0.42)	(-0.65)	(-0.57)

Table 2. Continued . . .

Table 2. Continued ...

	1992		
	Female	Male	Total
Regression number	1	2	3
Explanatory variables[a]:			
E_i	0.0223***	0.0251***	0.0241***
	(3.22)[b]	(3.26)	(3.28)
D_{2i}	-2.8478***	-2.8281***	-2.8364***
	(-3.25)	(-3.23)	(-3.24)
D_{3i}	5.1714***	5.2085***	5.1846***
	(4.26)	(4.30)	(4.28)
R^2	0.383	0.385	0.386
R^2 (adj.)	0.357	0.359	0.360
F-ratio	14.51***	14.62***	14.67***
n_1, n_2	3,70	3,70	3,70
D-W	2.06***	2.07***	2.06***
k,n	3,74	3,74	3,74
SEE	2.0527	2.498	2.0482
Intercept	-0.4909	-0.6796	-0.6039
	(-1.14)	(-1.43)	(-1.33)

* Significant at 10% level.

** Significant at 5% level.

*** Significant at 1% level.

[a] Definition of the variables are given under equations (1).

[b] Figures in parentheses are t values for the estimated coefficients.

Table 3. Estimated structural change regression coefficients for the relationship of the primary and secondary enrollment ratios, OPEC, EAC, and period dummy variable to per capita GNP growth of 1980-93, using pooled-cross-section data of 1950, 1955, 1960, 1965, 1970, 1980, and 1992, and equation (2).

	Total	Total	Female	Male	Total	Total
Regression number	1	2	3	4	5	6
Explanatory variables[a]:						
E_{it}	0.0122***	0.0131***	0.0174***	0.0208***	0.0195***	0.0236***
	(4.43)[b]	(4.44)	(5.54)	(6.39)	(6.03)	(6.40)
D_{2it}	-1.9364***	-1.9380***	-1.8986***	-1.90***	-1.8931***	-1.8629***
	(-6.12)	(-6.09)	(-5.77)	(-5.82)	(-5.78)	(-5.68)
D_{3it}	4.2136***	4.2038***	4.3733***	4.2680***	4.3182***	4.2552***
	(12.44)	(12.34)	(12.46)	(12.23)	(12.35)	(12.09)
D_{4it}(1955)		-0.0287				-0.1334
		(-0.08)				(-0.36)
D_{5it}(1960)		-0.2071				-0.1225
		(-0.57)				(-0.33)
D_{6it}(1965)		-0.1406				-0.2790
		(-0.39)				(-0.77)
D_{7it}(1970)		-0.0896				-0.3393
		(-0.26)				(-0.94)
D_{8it}(1980)		-0.3232				-0.6263*
		(-0.90)				(-1.67)
D_{9it}(1992)		-0.2289				-0.7170*
		(-0.63)				(-1.82)
R^2	0.292	0.293	0.320	0.333	0.327	0.334
R^2 (adj.)	0.288	0.282	0.316	0.329	0.323	0.323
F-ratio	75.50***	25.09***	82.48***	87.20***	84.14***	28.94***
n_1, n_2	4,549	11,542	4,524	4,524	4,524	11,517
D-W	2.01***	2.02***	1.95***	1.96***	1.96***	1.97***
k,n	4,554	11,554	4,529	4,529	4,529	11,529
SEE	2.1137	2.1229	2.1221	2.1029	2.1112	2.1125
Intercept	-0.5069*	-0.4256	-0.0196	-0.1955	-0.1168	0.0962
	(-2.17)	(-1.35)	(-0.15)	(-0.36)	(-0.84)	(0.35)

* Significant at 10% level.

** Significant at 5% level.

*** Significant at 1% level.

[a] Definition of the variables are given under equations (2).

[b] Figures in parentheses are t values for the estimated coefficients.

Table 4. Estimated piecewise regression coefficients for the relationship of the primary and secondary enrollment ratios, OPEC, EAC, and threshold dummy variable to per capita GNP growth of 1980-93, using pooled-cross-section data of 1950, 1955, 1960, 1965, 1970, 1980, and 1992, and equation (2).

	Primary	Secondary		
	Total	Female	Male	Total
Regression number	1	2	3	4
Explanatory variables[a]:				
E_{it}	0.0500***	0.0693***	0.0362***	0.0465***
	(3.83)[b]	(3.94)	(5.37)	(4.52)
D_{2it}	-1.9474***	-1.9248***	-1.9311***	-1.9261***
	(-3.20)	(-5.89)	(-5.96)	(-5.92)
D_{3it}	4.2430***	4.3576***	4.136***	4.1807***
	(12.61)	(12.52)	(11.79)	(11.91)
D_{10it}	-0.0311	-0.0485***	-0.0151***	-0.0247***
	(-2.96)	(-2.99)	(-2.60)	(-2.76)
	E^*=42[c]	E^*=23	E^*=53	E^*=36
R^2	0.303	0.333	0.341	0.337
R^2 (adj.)	0.298	0.328	0.336	0.332
F-ratio	59.62***	65.22***	67.81***	66.56***
n_1, n_2	5,548	5,523	5,523	5,523
D-W	2.00***	1.96***	1.98***	1.97***
k,n	5,554	5,529	5,529	5,529
SEE	2.0989	2.1053	2.0915	2.0981
Intercept	-1.1903***	-0.3032*	-0.4170**	-0.3851**
	(-3.64)	(-1.88)	(-2.51)	(-2.28)

* Significant at 10% level.

** Significant at 5% level.

*** Significant at 1% level.

[a] Definition of the variables are given under equations (2).

[b] Figures in parentheses are t values for the estimated coefficients.

[c] E^* = the threshold value for the enrollment ratio used in the regression.

Figure 1. The slopes of the lines of regression no. 1 in table 3 and no. 1 in table 4.

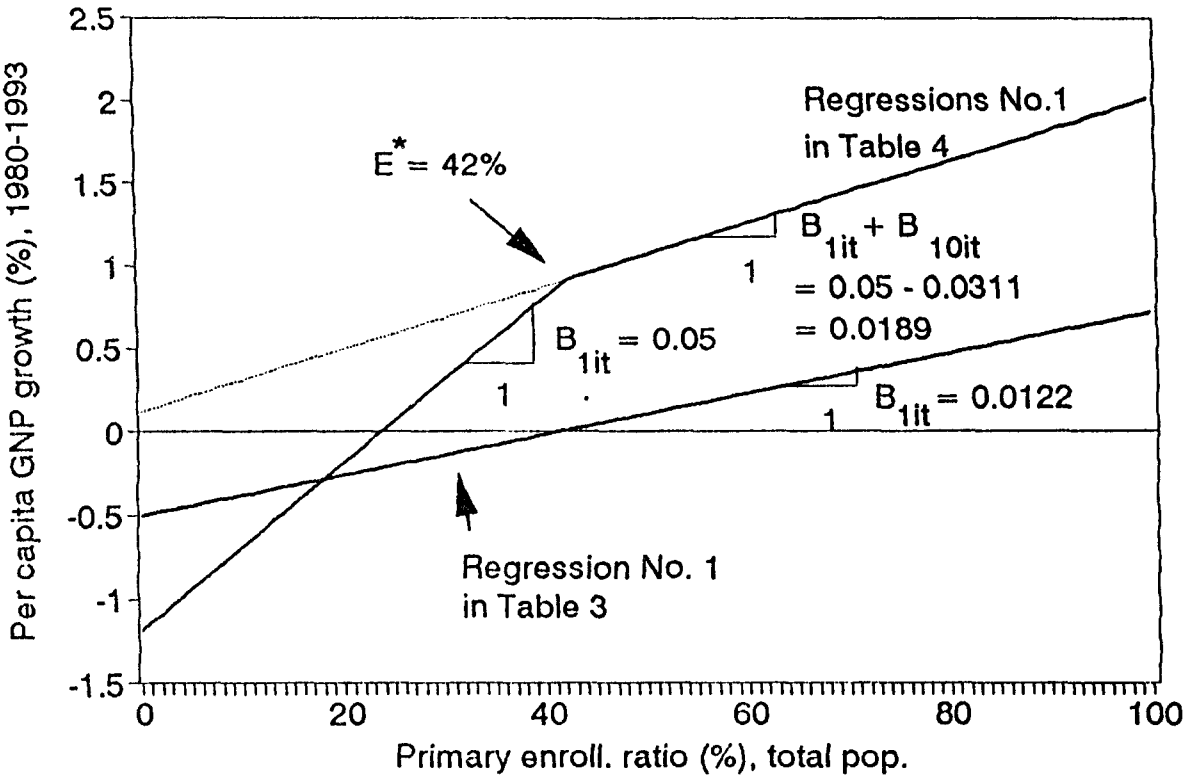


Figure 2. The slopes of the lines of regression no. 3 in table 3 and no. 2 in table 4.

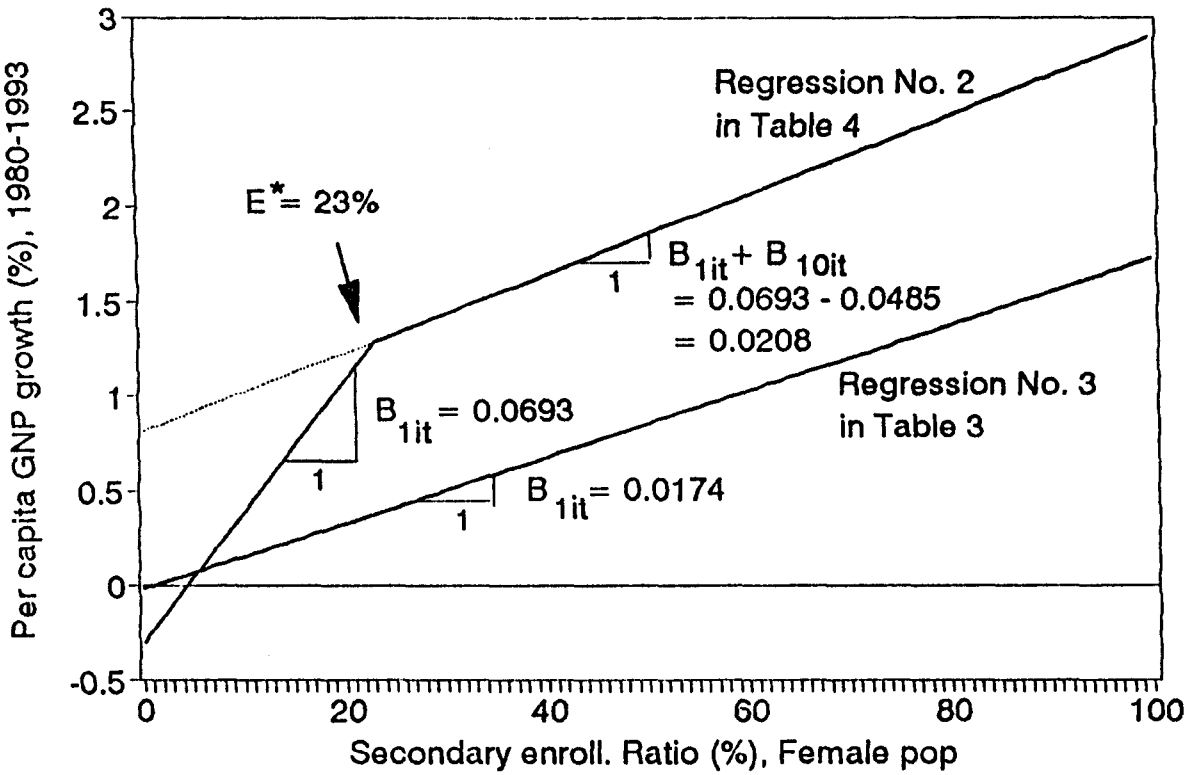


Figure 3. The slopes of the lines of regression no. 8 in table 3 and no. 3 in table 4.

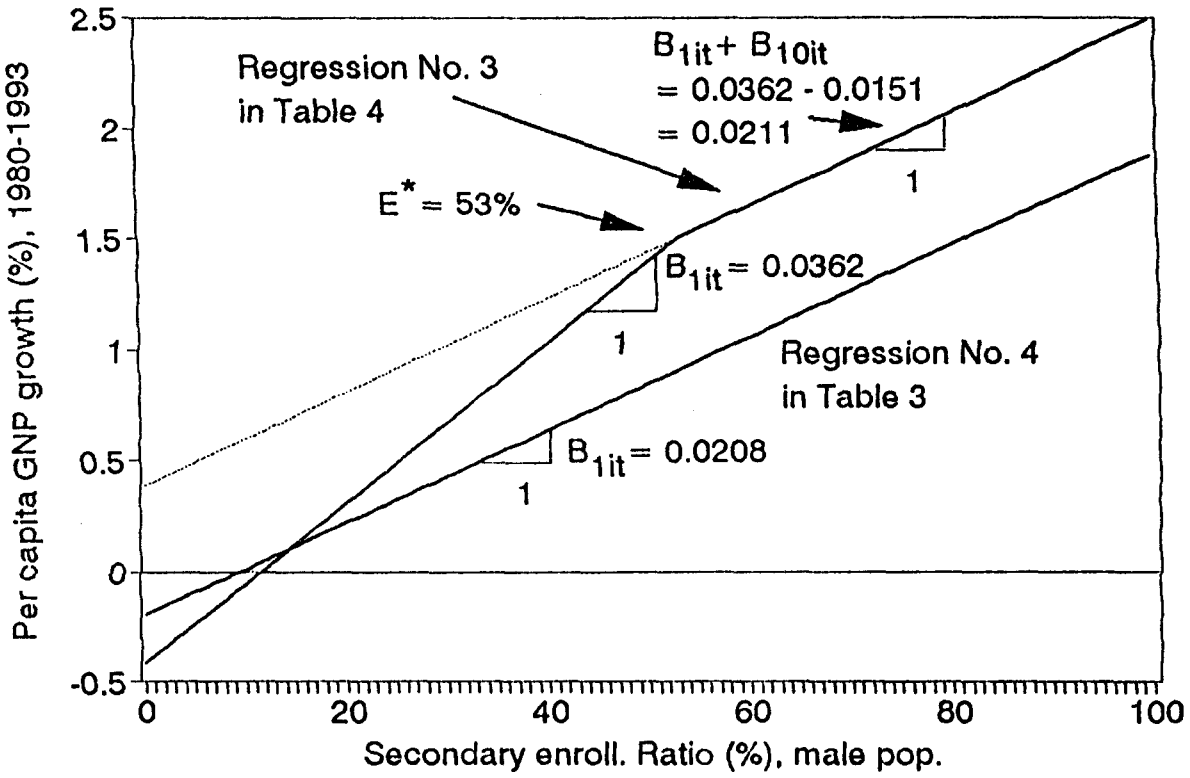
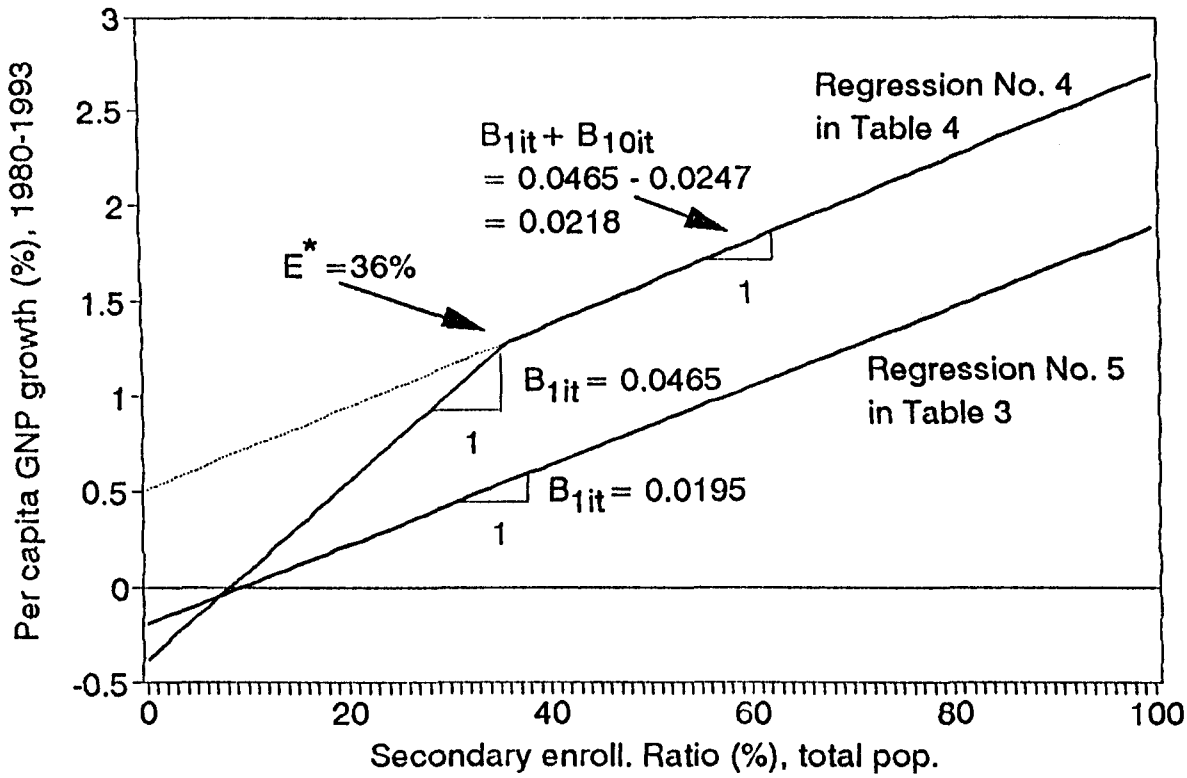


Figure 4. The slopes of the lines of regression no. 5 in table 3 and no. 4 in table 4.



The Economic Research Forum for the Arab Countries, Iran and Turkey (ERF) was established in June 1993 as an independent, non-profitmaking regional networking organization. Its mission is to promote policy-relevant economic research with a broad representation of views, and to help activate the policy-formulation debate in the region - by encouraging and funding quality research, and disseminating results of research activities to economists and policy-makers.

The ERF *Working Papers Series* disseminates the findings of research work in progress to promote the exchange of ideas, and encourage discussion and comment among researchers for timely revision and application by the author(s).

The *Working Papers* are a prepublication outlet intended to make preliminary research results available with the least possible delay. They are therefore subject to light editing *only* when strictly necessary, and ERF accepts no responsibility for errors.

ECONOMIC
RESEARCH
FORUM
FOR THE ARAB COUNTRIES, IRAN & TURKEY

7 Boulos Hanna Street, Dokki, Cairo, Egypt
Tel : (202) 3370810 - (202) 3485553 - (202) 3602882. Fax : (202) 3616042 or (202) 3602882
E-mail : HANDOUSA @ AUC-ACS.EUN.EG or ERF @ IDSC.GOV.EG